STATISTICAL ANALYSIS OF OHIO FLUTED POINTS[1]

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ABSTRACT

Fluted points are important as a marker of the Big Game Hunting Tradition in North America. A sample of 772 fluted points from Ohio is analyzed here; means, standard deviations, medians, and ranges of some measurements of these points are presented for six previously defined types: Convex-Parallel-Sided, Concavo-Convex-Sided, Ross County, Triangular, Pentagonal, and Holcombe. The following measurements are used to define the points: maximum length, maximum width, distance of position of maximum width from base, basal width, maximum thickness, distance of position of maximum thickness from base, depth of basal concavity, maximum length of fluting, and length of lateral grinding. In addition, the following discrete attributes were recorded: number of flutes, presence or absence of basal grinding, flint type, and provenience by physiographic region of the state. Point types are distinct in regard to most quantitative attributes, with the exception of Convex-Parallel-Sided and Concavo-Convex-Sided.

A cluster analysis of all possible correlations of quantitative variables was performed in order to isolate functional clusters from which principles of technique of manufacture might be inferred. There are three such clusters, or, presumably, principles of technique: (1) general size, (2), length-linearity, (3) fluting. For the discrete attributes, tests of association indicate that a fourth factor, edge and basal grinding (possibly to be interpreted as "degree of completion"), is present. By inference, the manufacturing process has four steps: determination of general size of artifact, shaping to proper length and width, thinning by fluting, and finishing by grinding. However, strength of clusters is only moderate, and there is both overlap of clusters and interdependence of attributes. Flint type and provenience vary independently of other attributes.

INTRODUCTION

The fluted point is unquestionably the most important artifact of the Big Game Hunting Tradition in most of North America. As the indicator of a specific cultural unit, it is comparable in significance to certain distinctive artifacts of the European Paleolithic. Its relative uniformity in shape over a transcontinental range and a 4000-year period (in eastern United States, from at least ca. 12,000 B.C. to ca. 8000 B.C.; cf. Willey, 1966, p. 456) is remarkable. In addition, owing

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to the paucity of early sites and other distinctive artifacts, it is the only easily recoverable Paleo-Indian tool.

Fluted points are particularly well suited to quantitative analysis, which, indeed, is necessary if any conclusions regarding distribution, manufacture, and use are to be drawn. Because of the great similarity in shape between points from places as distant as New Mexico and Massachusetts (Byers, 1954, p. 351), classifications based solely on a few morphological criteria are usually not useful in distinguishing small but significant variations. Also, measurements significantly and directly related to the manufacturing process can readily be made even on fragmentary specimens; and, finally, a surprisingly large number of points, reposing as the most cherished items in amateurs' collections, remain intact.

This note presents (1) a statistical description of all available fluted points in Ohio and (2) a correlational analysis of selected quantitative and qualitative attributes in order to infer some principles of manufacture. This is not a new approach. Prufer and Baby (1963) and Mason (1958) have made some use of such descriptive statistics, particularly in efforts to compare series from various regions. Fitting (1965a; 1965b), using the chi-square test, has isolated attribute clusters related to manufacture and has even inferred intra-site social patterns by a study of differential distribution of flint artifacts and chippage (Fitting, DeVisscher, and Wahla, 1966).

The present sample has been restricted arbitrarily to Ohio, because a detailed body of data from this state is readily available and because this area contains a representative group of most kinds of points found in eastern United States. For similar data from other areas, the reader is referred to the work of Fitting (1965a; 1965b). No attempt has been made here to compare the Ohio samples with those of other regions, partly because this would duplicate the work of Prufer and Baby (1963) and Mason (1958), and partly because the comparison of each attribute from region to region would make both this project and this report unwieldy.

NATURE OF THE SAMPLE

The sample consists of 772 points collected from all parts of the state of Ohio. About 410 points are complete, the remainder being fragmentary or insufficiently described. By far the majority of the data were obtained from published and unpublished records of Dr. O. H. Prufer, who assiduously measured and illustrated specimens from local collections and from museums during a period of some seven years. Prufer did not provide detailed statistical analyses, nor was this his intention. Data on about 530 points were published in *Survey of Ohio Fluted Points* (Prufer, 1960a; 1960b; 1960c; 1961a; 1961b; 1961c; 1962a; 1962b; 1963) and in a general summary by Prufer and Baby (1963). Other information was obtained from Prufer's unpublished notes (in the possession of O. H. Prufer, Kent State University). Incomplete data on a few recently illustrated artifacts can be found in *The Ohio Archaeologist* (Anonymous, 1966a; 1966b; 1968; Hankins, 1967; 1969). Most of the points were surface finds discovered by local collectors.

PROCEDURE

Prufer originally defined eleven measurements to be made on each specimen (1960a, p. 3). No additional measurements could be added, since the points were not available and could only be viewed from drawings or photographs. These measurements form the basis for this study and are as follows:

1. Maximum length. Measured from tip to basal "ears".
2. Maximum width.
3. Distance of position of maximum width from base.
4. Basal width.
5. Maximum thickness.

6. Distance of point of maximum thickness from base.
7. Depth of basal concavity.
8. Maximum length of fluting, side A. "Side A" refers to the "obverse" side in Prufer's published and unpublished descriptions. This was the pictured side, usually selected because of distinctive fluting or special characteristics.
9. Maximum length of fluting, side B. "Side B" refers to the "reverse" side in Prufer's descriptions. It is not pictured, and, since the illustration was made to show the kind of fluting, is more often unfluted than is the obverse ("A") side. (This distinction was of course not made by the flint knapper).
10. Length of lateral grinding along the right edge as seen from side A.
11. Length of lateral grinding along the left edge as seen from side A.

The factor of maximum constriction above the base used by Prufer (1960a, p. 3), was omitted because of the small number of such measurements.

The choice of these eleven measurements is designed to give a picture of both size and shape. They are illustrated in Figure 1. Whether they in fact do present a complete and efficient description of the point will be discussed in a subsequent section of this report.

In addition, observations were made on six other, discrete attributes:

1. Number of flutes, side A.
2. Number of flutes, side B.
3. Number of flutes, total of side A and side B.
4. Presence or absence of basal grinding.
5. Flint type. Ohio Paleo-Indians preferred certain flint sources (Prufer and Baby, 1963, p. 44–48). Best known is ***Flint Ridge*** flint from Licking County in eastern Ohio. It is easily distinguishable by its bright colors, sheen, and crystalline inclusions. ***Upper Mercer*** flint occurs in a widespread Pennsylvanian limestone formation in eastern Ohio. Typically shiny black, it may also be gray, dull blue, or banded. Most Upper Mercer flint used for artifacts probably came from Coshocton County, where aboriginal mining pits of undetermined age are present. ***Plum Run*** flint is an uncommon type from Stark County (near Canton, Ohio). The most common foreign types are ***Onondaga Chert*** from western New York (Witthoft, 1952, p. 470–71) and ***Indiana "Hornstone"*** from eastern Indiana. Also present is ***Elkhorn Creek*** flint from Kentucky. Flint other than these types or kinds and not definitely identified were classified for the purposes of this paper as "common" (assumed to be of local origin) or "rare" (assumed to be from outside of the Ohio region). A few points were made of quartzite, usually identified in the fluted-point-survey notes as from Pennsylvania. For additional information on flint types, the reader is referred to Prufer and Baby's discussion (1963, p. 44–48).
6. Region. Although not associated with the manufacturing process, this attribute was included in the event that attributes might vary between regions of the state. County locations were available for most points and exact locations of surface finds for many. Locations are classified here according to physiographic divisions:
   (a) the Lake Plains (all areas within the Erie-Maumee basin),
   (b) the glaciated Central Lowlands,
   (c) the Glaciated Appalachian Plateau in northeastern Ohio, and
   (d) the Unglaciated Appalachian Plateau in southeastern Ohio.

The factor of presence or absence of basal nipple (Prufer, 1960a, p. 3) was omitted because of the rarity of this remnant of the fluting process.

The statistical procedure involved, first, recording each specimen on McBee

Keysort Cards (K–5S–581B), a technique suggested by Fitting's work (1965a). Thus, combinations of attributes to be statistically tested could easily be selected.

In the following sections, the mean, standard deviation, median, and range for each quantitative attribute are presented. For analysis of association of quantitative attributes, Pearson's product-moment correlation (Blalock, 1960, p. 273–301) was used. Inspection of scattergrams indicated approximate bivariate normality, and equality of variances (homeoscedasticity) was assumed (Blalock,

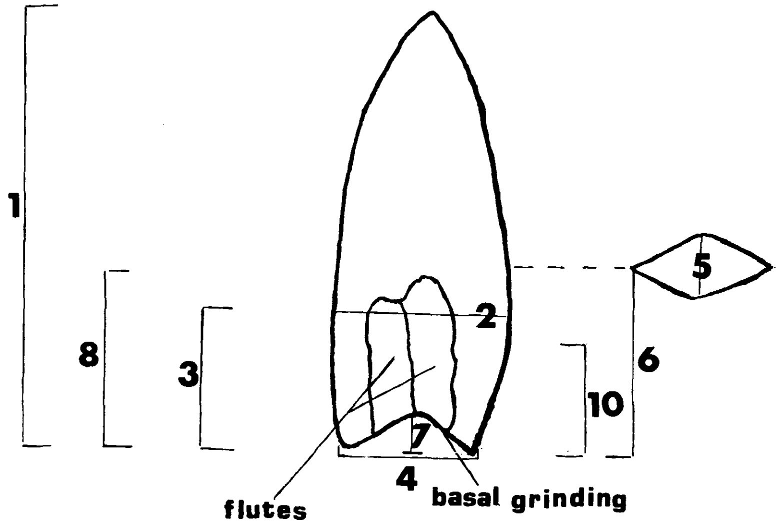

FIGURE 1. Fluted point attributes (Refer to p. 353–354).

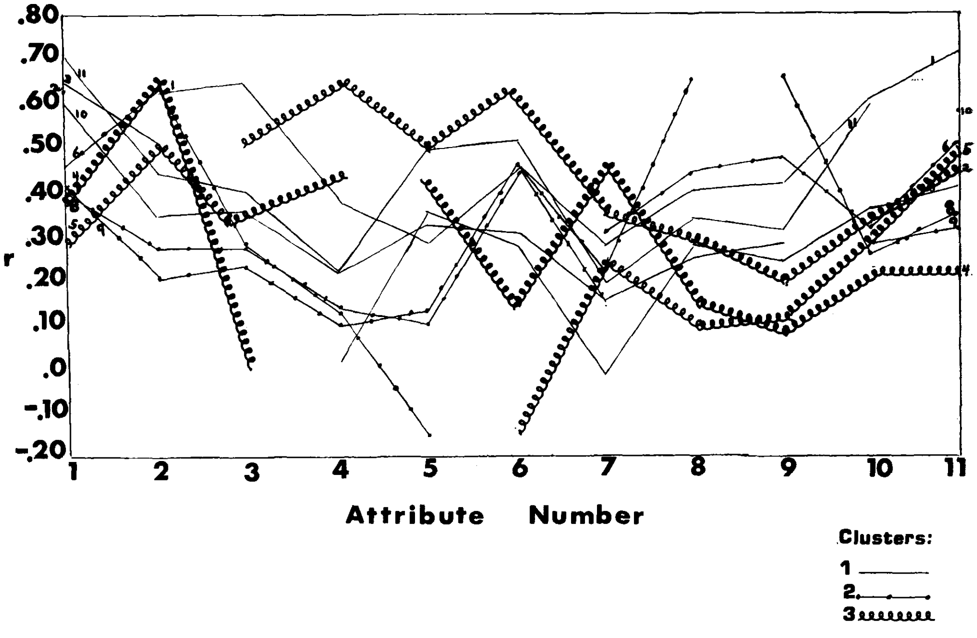

FIGURE 2. Correlational profiles, showing clusters.

1960, p. 279). For ease in computation, data were grouped according to the procedure outlined by Blalock (1960, p. 292–294). Chi-square tests were used to test relationships between continuous and discrete variables and between two discrete attributes (Spaulding, 1960). The strength of significant associations was measured by Cramer's V, a statistic measuring strength of association (Blalock, 1960, p. 230; Sackett, 1966, p. 367). In many cases, categories in the chi-square tests had to be combined to meet the minimal cell-frequency requirements of the test. The criteria and procedures for combination of frequencies used were those proposed by Simpson, Roe, and Lewontin (1960, p. 189–91, 322–23).

METRICAL DESCRIPTION OF OHIO FLUTED POINTS

This section supplements Prufer and Baby's analysis (1963) by virtue of the larger sample now available and the fact that data more detailed than those of Prufer and Baby can now be presented. It may thus be of use to those desiring to compare the Ohio sample or sub-samples with data from other regions.

The information is presented in Table 1 and is divided according to the types set up by Prufer and others. Prufer and Baby (1963, p. 19–20), wishing to make some sense out of the unacceptably broad "eastern Clovis" and "Folsom" designations, defined five types, largely on the basis of physical form. Convex-Parallel-Sided and Concavo-Convex-Sided are long points with straight to slightly curving sides. The Ross County type, most common in the Scioto Valley, is a very large, broad point with broad flaking and fluting. In the Triangular type, basal width equals maximum width. Pentagonal points have clearly angular shoulders. The Holcombe point, defined from a Michigan sample (Fitting, DeVisscher, and Wahla, 1966; Wahla and DeVisscher, 1969), is a rather small, narrow point commonly fluted on only one side; in Ohio, it is almost entirely restricted to the lake plain and to the McKibben site in Trumbull County. The narrow, sinuous-sided Cumberland type occurs in Ohio, but is more common south of the state. In addition, 76 fluted points of undetermined type were included in the combined measurements.

A variety of statistical operations—tests for significance of difference, measures of variability, etc.—could be performed on these types. These are omitted here because these data are meant to be purely descriptive and because a type dignified with too much attention ". . . embarks on an independent existence of its own. At that point the classification ceases to be a 'tool' and the archaeologist becomes one" (Phillips, Ford, and Griffin, 1951, p. 62). However, the following characteristics may be noted. The Ross County type is clearly distinct in most measurements. Pentagonals and Holcombes are evidently smaller than the others, and the latter is further distinguished by narrowness, thinness, and frequent lack of fluting. The Convex-Parallel and Concavo-Convex types are metrically almost identical, so much so that it is difficult to assign a point with certainty to the correct type, using the information provided in published descriptions and notes. Prufer and Baby recognized the tentativeness of the Concavo-Convex type (1963, p. 15); in view of the larger sample now available, it seems advisable to combine the two into one type with the designation Convex-Parallel-Sided.

Some variation in raw material can be noted. Pentagonal and Cumberland points are made of foreign (or rare) flints somewhat more commonly than are the others, a difference that possibly indicates manufacture outside of Ohio. On the whole, however, local raw materials were selected, as Prufer and Baby pointed out (1963, p. 48). In regard to distribution, it is clear that Ross County, Triangular, and Cumberland points are rare in the lake plains, but that Pentagonal and Holcombe are concentrated both here and in the adjacent glaciated Appalachians (nine Holcombe specimens were derived from one surface site—McKibben in Trumbull County; cf. Prufer and Sofsky, 1965, p. 13).

TABLE 1

Ohio fluted point types

Attribute		Convex-Parallel (N=337)	Concavo-Convex (N=125)	Ross County (N=57)	Triangular (N=72)	Pentagonal (N=43)	Cumberland (N=38)	Holcombe (N=24)	Total Sample (N=772)*
Maximum Length	N	248	105	51	66	34	32	4	557
	$\bar{X}$	69.54	67.45	87.26	59.35	43.17	68.88	53.00	67.04
	s	21.02	19.41	13.46	18.90	8.92	13.84	———†	21.87†
	Md	66.60	65.53	88.30	55.69	43.03	68.40	47.00	———
	R	28–138	34–137	63–114	30–121	28–63	46–105	45–62	19–138
Maximum Width	N	277	113	51	63	36	34	9	614
	$\bar{X}$	26.88	27.86	31.45	25.30	25.50	25.64	21.00	27.01
	s	3.76	3.35	3.34	3.37	4.62	6.30	———	4.28
	Md	27.05	27.23	31.48	25.41	25.50	23.50	19.00	———
	R	15–40	20–41	22–38	15–31	17–38	15–34	17–38	7–41
Max. Width-Dist. from Base	N	203	97	43		34	29	7	493
	$\bar{X}$	29.08	28.52	41.25	at	25.79	30.55	17.43	28.96
	s	16.62	13.18	8.95	base	5.89	2.77	———	10.62
	Md	28.00	30.17	39.86		17.50	32.67	16.00	———
	R	0–73	0–65	12–66		0–32	26–57	0–31	0–73
Width at Base	N	211	102	43	63	32	28	12	515
	$\bar{X}$	23.31	23.74	26.35	25.30	22.19	19.08	12.08	23.19
	s	3.83	3.83	3.08	3.37	3.88	4.47	———	4.22
	Md	23.33	24.00	26.75	25.41	21.69	18.97	17.00	———
	R	13–35	15–30	19–31	15–31	15–33	8–32	14–20	8–35
Maximum Thickness	N	202	91	41	58	37	32	8	500
	$\bar{X}$	7.12	6.80	8.04	7.01	6.04	6.50	4.38	6.91
	s	1.44	1.31	1.28	1.23	1.20	1.29	———	1.39
	Md	7.15	6.86	8.00	7.12	5.85	6.27	4.50	———
	R	3–12	3–11	5–10	5–12	4–9	3–9	3–6	3–12
Maximum Thickness-Dist. from Base	N	184	84	38	53	36	30	4	447
	$\bar{X}$	36.79	34.15	42.34	32.04	27.20	36.00	20.50	34.83
	s	13.80	11.97	11.33	13.20	5.60	10.92	———	11.51
	Md	35.24	33.91	41.04	29.88	28.87	37.60	20.00	———
	R	5–107	4–65	19–72	0–90	12–38	8–56	14–28	0–107
Basal Concavity	N	220	101	45	59	32	31	16	534
	$\bar{X}$	4.12	3.93	5.03	4.51	3.62	3.02	3.00	4.12
	s	2.01	1.22	1.65	1.87	1.62	1.31	———	1.50
	Md	4.06	4.12	4.38	4.44	3.64	2.94	2.17	———
	R	0–10	0–9	1–9	0–9	0–8	1–7	1–9	0–11
Flute Length-Side 'A'	N	210	98	46	61	35	22	8	500
	$\bar{X}$	30.55	30.61	32.91	29.93	26.36	48.32	18.38	30.73
	s	13.14	11.85	10.41	12.97	6.18	13.99	———	12.86
	Md	28.75	29.53	32.32	28.00	25.97	47.64	19.50	———
	R	8–105	9–66	15–70	14–70	14–41	22–77	12–29	8–105
	Absent	4	0	0	0	0	8	2	16
Flute Length-Side 'B'	N	198	84	44	59	34	22	5	458
	$\bar{X}$	28.89	26.69	31.25	28.10	24.40	43.68	10.40	28.76
	s	12.18	11.48	11.22	10.64	6.60	16.54	———	12.17
	Md	29.04	25.24	28.40	23.00	23.57	42.17	10.00	———
	R	5–75	9–74	11–68	12–60	19–98	15–80	7–14	5–98
	Absent	30	9	4	5	6	11	10	75
Number of Flutes-'A' (%)	N	314	118	55	72	42	38	23	731
	0	1.28%	1.70%	1.82%	0.0%	0.0%	21.05%	8.70%	2.31%
	1	67.19	66.98	47.32	62.50	66.66	65.78	26.09	64.64
	2	20.06	18.63	40.04	23.61	21.49	10.52	47.83	21.60
	3	9.23	4.22	3.64	9.72	9.51	2.63	13.04	7.79
	4	0.96	1.70	1.82	1.39	2.37	0.0	0.0	1.09
	>4	1.28	6.79	5.46	2.78	0.0	0.0	4.35	2.59

TABLE 1—*Continued*

Attribute		Convex-Parallel (N=337)	Concavo-Convex (N=125)	Ross County (N=57)	Triangular (N=72)	Pentagonal (N=43)	Cumberland (N=38)	Holcombe (N=24)	Total Sample (N=772)*
	N	283	110	52	69	38	38	23	674
	0	11.66%	8.18%	9.62%	8.69%	15.80%	28.95%	43.47%	13.80%
Number of Flutes-'B' (%)	1	58.64	58.24	58.24	71.00	42.10	57.89	34.78	57.86
	2	22.61	15.44	13.46	14.49	34.21	10.52	0 0	18.55
	3	4.95	11.81	7.69	4.35	5.26	2.63	17.39	6.53
	4	0.71	0.0	0.0	0.0	0.0	0.0	0.0	0.30
	>4	1.41	6.35	11.54	1.45	2.63	0.0	4.35	2.97
	N	178	76	42	55	35	27	4	431
	$\bar{X}$	27.07	26.55	34.55	28.06	21.64	26.20	20.25	27.73
Lateral Grinding-Rt.	s	7.82	6.34	8.18	12.43	4.08	6.71	——	8.65
	Md	27.75	26.41	34.18	25.75	20.77	26.87	19.00	——
	R	5-54	13-40	17-52	5-80	11-29	6-42	15-28	5-80
Absent		28	11	0	12	0	3	5	59
	N	172	79	41	55	31	25	3	418
	$\bar{X}$	26.72	26.51	34.77	25.97	20.33	23.89	31.33	26.72
Lateral Grinding-L.	s	8.34	8.05	8.74	14.69	4.08	7.11	——	9.67
	Md	27.82	26.52	34.67	24.94	21.20	23.42	20.00	——
	R	8-76	8-42	14-53	7-56	13-28	12-41	20-24	7-76
Absent		30	10	0	11	2	3	4	60
	N	283	116	54	66	39	11	4	621
Basal Nipple (%)	Pr	1.06%	0.0%	0.0%	1.50%	0.0%	63.64%	25.00%	1.93%
	Ab	98.94	100.0	100.0	98.50	100.0	36.36	75.00	98.07
	N	258	106	47	61	35	34	20	606
Basal Grinding (%)	Pr	86.16%	86.40%	97.87%	83.61%	88.60%	79.41%	70.00%	84.82%
	Ab	13.84	13.60	2.13	16.49	11.40	20.59	30.00	15.18
	N	276	113	44	57	32	28	20	626
F Upper Mercer		44.53%	40.71%	34.08%	33.34%	25.00%	32.15%	85.00%	41.69%
L Flint Ridge		15.57	22.13	31.81	22.81	25.00	21.43	0.0	18.69
I Plum Run		1.09	1.77	2.27	0.0	0.0	0.0	0.0	1.28
N local-common		17.38	14.16	15.90	15.79	25.00	17.86	10.00	16.45
T Onondaga Chert		5.07	5.31	4.55	14.04	6.25	3.57	5.00	6.07
T Indiana Y Hornstone		6.52	1.77	4.55	5.26	0.0	10.71	0.0	4.95
P Elkhorn Creek		1.45	1.77	2.27	3.51	0.0	0.0	0.0	1.60
E foreign-rare		6.88	10.62	4.55	5.26	15.60	14.32	0.0	7.99
(%) quartzite		1.44	1.77	0.0	0.0	3.12	0.0	0.0	1.28
R	N	333	125	53	72	41	35	22	751
E Lake Plains		6.31%	7.20%	0.0%	6.95%	46.40%	5.71%	18.18%	7.99%
G Central I Lowland		49.55	44.00	67.90	52.78	12.20	54.26	9.09	45.54
O Glaciated N Appal.		20.72	24.80	13.20	18.06	24.40	17.14	50.00	22.10
(%) Unglac. Appal.		23.42	24.00	18.86	22.23	17.10	22.86	22.72	24.37

Notes: All measurements in millimeters; measurements were taken with calipers to the nearest millimeter.
Percentages may not add up exactly to 100.00% due to rounding.
*Includes 76 points of undetermined type.
†Holcombe s omitted because of the small sample sizes and is not included, in any case, in s_c.

ATTRIBUTE ANALYSIS

The foregoing discussion was concerned merely with a description of previously-defined fluted point types. This section is concerned with a quite different problem: the isolation of attribute clusters which may permit inferences regarding manufacture of the fluted point. For this purpose the entire sample has been used, irrespective of type.

A correlation matrix of eleven variables is presented in Table 2. Significant associations of attribute pairs and the strength of the association as measured by V are presented in Table 3. In this table, only associations in which $p \leq .05$ are shown. The average number of variables available for correlation and associational analysis is about 450, considerably less than the total sample of 772 because of incomplete data or breakage.

Inspection of Table 2 indicates that the values of the correlation coefficients (r) are relatively low: r is over 0.40 in only 19 of 55 correlations, despite the presence of several "built-in" correlations (e.g., flute length is limited by maximum length). Although the large sample size makes all values statistically significant from zero, in many cases they are trivial. In Table 3 only 21 probability values at the 0.05

TABLE 2

Product-moment correlations of fluted point attributes

	1	2	3	4	5	6	7	8	9	10	11
1. Maximum Length	—	.620	.638	.381	.292	.462	.283	.398	.408	.604	.702
2. Maximum Width	.620	—	.502	.630	.499	.622	.368	.278	.206	.354	.441
3. Max. W. from base	.638	.502	—	.028	.356	.283	−.019	.277	.246	.361	.396
4. Width at base	.381	.630	.028	—	.424	.126	.427	.137	.102	.217	.218
5. Max. Thickness	.292	.499	.356	.424	—	−.162	.243	.100	.132	.330	.488
6. Max. Thickness from base	.462	.622	.283	.126	−.162	—	.312	.446	.463	.306	.508
7. Basal Concavity	.283	.368	−.019	.427	.243	.312	—	.154	.217	.149	.194
8. Flute Length-A	.398	.278	.277	.137	.100	.446	.154	—	.660	.262	.335
9. Flute Length-B	.408	.206	.246	.102	.132	.463	.217	.660	—	.283	.309
10. Lateral Grinding-R	.604	.354	.361	.217	.330	.306	.149	.262	.283	—	.576
11. Lateral Grinding-L	.702	.441	.396	.218	.488	.508	.194	.335	.309	.576	—

TABLE 3

Significant associations of attributes

	Attribute pairs	P	V
1.	Number of flutes, side A—Number of flutes, side B	.001	.264
2.	Number of flutes, sides A+B—Basal width	.001	.221
3.	Number of flutes, side B—Basal width	.001	.213
4.	Number of flutes, side A—Basal width	.01	.185
5.	Number of flutes, side B—Flute length, side B	.05	.129
6.	Presence/absence of flutes, side A—Presence/absence of flutes, side B	.05	.088
7.	Presence/absence of lateral grinding, right side—Presence/absence of lateral grinding, left side	.001	.906
8.	Basal grinding—Number of flutes, side B	.001	.739
9.	Basal grinding—Presence of lateral grinding, left side	.001	.686
10.	Basal griding—Presence of lateral grinding, right side	.001	.648
11.	Basal grinding—Presence of basal concavity	.001	.295
12.	Basal grinding—Basal width	.001	.213
13.	Basal grinding—Number of flutes, sides A+B	.001	.189
14.	Basal grinding—Flute length, side B	.001	.184
15.	Lateral grinding, left side—Presence/absence of flutes, side B	.001	.164
16.	Lateral grinding, right side—Number of flutes, sides A+B	.05	.126
17.	Presence/absence of basal grinding—Maximum length	.05	.105
18.	Lateral grinding, right side—Presence/absence of flutes, side B	.05	.093
19.	Maximum length—Flint type	.02	.141
20.	Flute length, side B—Region	.05	.132

level or better remain out of 88 chi-square tests. Moreover, most of the V coefficients are relatively low, although Sackett considers a V value of 0.125 "not particularly weak for lithic attribute clustering" (1966, p. 368).

Correlation is relatively high for maximum length, maximum width, and distance of position of maximum thickness from base five other variables (table 2). Fluting lengths produce low or moderate correlations with all variables except each other, where the correlation is high. Basal concavity is weakly related to most variables, a point previously established by Fitting (1965a, p. 366).

To clarify these relationships and others not immediately apparent, a cluster analysis was attempted (Fruchter, 1954; see also Clement, 1954, for application to ethnological data, and Driver, 1954, for bibliography). This is a simple technique for placing intercorrelated variables into natural groupings. The term "cluster analysis" seems to be used in anthropological data analysis to include various techniques (Driver, 1954; Sackett, 1966). In this paper, the technique referred to is the establishment of clusters by the use of Holzinger and Harman's B-coefficient (Fruchter, 1954, p. 12–17). In this technique the criterion for placing variables in a cluster is the B-coefficient, the ratio of the mean intercorrelations in the cluster to the mean of the remaining intercorrelations in the matrix. The B-coefficient should equal at least 1.30 for the cluster to be valid, and values over 2.00 are preferable. Thus, not only must variables in a cluster correlate highly with each other, but the pattern of correlations of each with all other variables must be similar. Cluster analysis of this kind, while easier to accomplish than factor analysis, is less precise and more subjective; clusters overlap and the investigator must decide with the help of the B-coefficient and his knowledge of the data which of a number of possible clusters are most meaningful.

Three clusters were established for these data, after considerable trial and error. Cluster one includes maximum length, distance of position of maximum width from base, lateral grinding along right edge, and lateral grinding along left edge. The B-coefficient is a relatively low 1.64. Cluster two includes length of fluting on side A, length of fluting on side B, and distance of position of maximum thickness from base; here B equals 1.99. Cluster three includes maximum width, basal width, and maximum thickness; B equals 1.86. One variable, basal concavity, could not be acceptably fitted into any cluster.

Cluster one appears to be a group of length-associated variables. The high correlation of length with lateral grinding is in fact somewhat surprising in view of the restricted range of length of edge grinding (rarely under 20 mm or over 40 mm). A rather obvious inference is that a major part of the manufacturing process consisted of selecting a desired length and shaping the point to it.

Cluster two is related to fluting and the thinning accomplished thereby. Prufer has shown (Prufer and Wright, 1967) that fluting was by no means the final step in manufacture, but rather was a preliminary, often multiple process applied to the roughly shaped blank in order to thin it for further fine lateral flaking. The high correlation between length of fluting on side A and length of fluting on side B implies that the knapper struck off flutes with a conscious attempt to keep them approximately equal in length, certainly in one continuous operation, possibly alternately. The relation of position of maximum thickness to base was of course determined by fluting length. Maximum thickness, however, cannot be included in this cluster (correlation with fluting lengths: $r=0.100$, $r=0.132$). The implication is that artifact thickness was determined prior to fluting, at least in part, by preliminary shaping.

Cluster three relates to width and, with maximum thickness taken into account, may reflect the general size or massiveness of the blank from which the finished point was derived. The interpretation of this cluster is not clear.

This cluster analysis, it should be emphasized, is not the sole solution. For example, maximum length and width are highly correlated ($r = 0.620$). These variables might be used to start a cluster. However, they were not so used because maximum width does not correlate particularly highly with any variable showing a high correlation with maximum length and vice versa; thus, a cluster containing these two variables would have little explanatory value. Figure 2, showing correlational profiles, may help to visualize the clusters. It indicates general similarity in profile of the variables in the three clusters, but it also shows some dissimilarity and overlapping.

The preceding type of cluster analysis is not applicable to the V-values shown in Table 3. Attribute pairs listed here were divided by inspection only (no other grouping methods being used) into two groups comparable to the clusters established by B-coefficients. However, the criteria for grouping were not only V-values, but also similarity in type of attribute. For example, those pairs containing attributes related to grinding were grouped.

The first group thus established is composed of attribute pairs numbered 1–6 in Table 3. It seems to represent a series of associations related to the fluting process, although none are particularly strong. Analysis of the contingency tables from which the chi-square and V-values were obtained shows three reasons for the associations: (1) increase in basal width is related to increase in the number of flutes; (2) a tendency exists toward equality in the number of flutes per side (for example, if there is one flute on side A, there is one—not two or three—on side B); and (3) a weak tendency is evident for short flutes (<20 mm long) to be associated with multiple flutes—three or more—possibly an effect of the Holcombe type sample, in which this association is typical.

The second group (pairs numbered 7–18 in Table 3) is a series of attributes related to edge and basal grinding; some of these coefficients are quite strong. There is a definite tendency for the lateral grinding on the right or left edges to be uniform, i.e., if grinding is absent on one side, it is normally not present on the other side. Likewise, if lateral grinding is absent, basal grinding is also usually absent. Absence of flutes tends to be associated with absence of grinding. Since grinding was presumably the final step in the manufacturing process, these associations, taken together, may represent a factor of completion of manufacturings. Some associations seem to link basal grinding and basal configuration. Thus lack of basal grinding is associated with a shallow basal concavity; apparently the basal concavity was partly formed by grinding. Lack of basal grinding is also associated—in this case for no apparent reason—with narrow (<20 mm) or very wide (>35 mm) bases. Finally, there is a weak and unexplainable association between very long points (>90 mm) and presence of basal grinding.

Two associations (nos. 19–20 in Table 3), between maximum length and flint type and between flute length on side B and region are weak, and the interpretation is unclear because no one cell in the contingency table contributes significantly to the total chi-square value.

The analysis of these associations thus adds a fourth cluster, grinding (or, in part, a completion factor), to the three previously defined, and confirms the previously established cluster related to fluting. Again it should be emphasized that the clusters or associated pairs of attributes defined here have been rather subjectively selected and in no way represent the only clusters that might be proposed.

Since by definition these groups or clusters are not composed of randomly related variables and since there is evidently no factor other than that of technique to unite them, they are assumed to represent outcomes of the manufacturing process—by implication, the results of subsets of the total technical process and the ideals motivating it. The conclusion is that the Paleo-Indian artisan had at least four steps in the making of a fluted point: (1) determination of the overall size and the general massiveness of the artifact; (2) selection and production of an ideal length and degree of linearity; (3) thinning and shaping by fluting; and (4) finishing the point by smoothing the edges. The third and fourth operations sometimes seem incomplete, possibly owing to poor technique, material, or the intended use of the point.

However, none of these operational steps is strongly unified, as shown by the usually modest magnitude of the measures of association. There is much overlap between attributes and, conversely, many attributes are weakly or non-significantly correlated with the others. To continue this line of reasoning, this perhaps implies that, while the making of a fluted point was a single process and the result a functional whole, a large number of separate and independent technical activities went into it. The goal was realized through the use of many minor different processes.

Two of the attributes have virtually nothing to do with point manufacture or point types. One of these is flint source, the choice of which must have been mainly directed by convenience. The second unrelated attribute is physiographic region, at least as they have been defined here. It was perhaps ill-advised to expect ecological correlates, given the minor differences between the regions. No meaningful associations are present, and there is no significant concentration of points in any one of the four regions. Any regional differences in attributes would thus be due to diffusion of the various types from various directions—Holcombe from the north, for example—so that a simple division of Ohio into four quarters, or according to river drainage areas, might have produced more significant results.

METHODOLOGICAL DISCUSSION

A methodological aspect of this analysis remains to be discussed: the validity of the statistical procedure. In statistical tests of the kind applied here, two problems may arise: (1) the problem of interdependence of attributes, and (2) the problem of efficient selection of attributes. Interdependence of attributes can be further subdivided into two parts: (a) redundancy of quantitative attributes, and (b) interaction of discrete attributes both with each other and with grouped quantitative attributes.

In regard to redundancy, it is clear that some automatic functional correlates will appear. Thus, length of fluting is correlated with length of point, since the former is limited by the latter. Basal width is similarly a function of maximum width, which in turn is partly dependent upon total length (for after a certain length/width ratio has been reached, a point will become too wide to be useful). In other words, correlation coefficients have been increased by an unknown amount through this interdependence. Moreover, since the purpose of the analysis was to establish functional clusters related to manufacture, this built-in functional interrelationship makes these clusters somewhat redundant.

The problem of interaction has been thoroughly discussed by Sackett (1966; 1969), who defines it as "the condition wherein statistical associations between specific attributes vary according to the presence or absence of other attributes with which they are contingently related" (Sackett, 1966, p. 371). For example, basal grinding has been shown to be associated with multiple fluting; however, one must ask to what extent this is true when basal width, which is associated with both attributes, is held constant. It would be necessary in this instance to test the grinding-fluting relationship of "narrow" points (as they were classified in this study) separately from that of "wide" points. Hidden mechanical relationships may be found if variables are controlled in this way; evidently a large number of controlled tests must be made. The method for controlling for interaction, therefore, although involving only the chi-square test, is lengthy and complex. Sackett (1966, p. 372–82) and Blalock (1960, p. 234–39) provide instructions for this method.

Control of interaction seems particularly important when it is desired to differentiate clusters due to cultural preference of the manufacturers from those resulting from mechanical necessity in manufacture. Although the clusters in this study are by definition functional, controls for interaction should be introduced, particularly if more attributes defining the fluted point are added.

Selection of attributes for analysis also presents a problem. The eleven metric and six discrete attributes utilized in this paper were selected by necessity, since they were the only attributes reported and since virtually none of the fluted points measured are readily available for restudy. However, additional observations may be made on fluted points. Binford (1963) has proposed an elaborate attribute list making use of some 51 separate observations and applicable to all kinds of projectile points; in this system, a number of attributes define shape of base and stem and kind of flaking. Benfer (1967) has suggested that 40 observations, including 24 measurements, be made on Texas Archaic projectile points, although Sackett (1969) has pointed out that excessive interaction is present in this group.

It is probable that addition of attributes to the relatively few employed in this paper would produce more clusters and might modify or refine the present clusters. In particular, observations on flaking would be valuable. On the other hand, increase in number of attributes means a considerable increase in time, particularly for a large sample; consequently, the investigator should have some theoretical or empirical evidence that addition of attributes would indeed provide more detailed or more significant results.

SUMMARY

1. A statistical description of all types of Ohio Fluted points has been presented.

2. A correlation matrix of 11 quantitative attributes has been prepared. Correlation coefficients are moderate to low. Non-parametric tests of significance and association are used to relate discrete attributes; coefficients of association are likewise relatively low in value.

3. In an attempt to isolate functional groups of attributes from which aspects of the manufacturing process might be inferred, cluster analysis of correlated and associated attributes has been undertaken. This analysis indicates that the processes of fluted-point making were basically, in this order: (1) determination of overall size, (2) determination of degree of linearity, (3) the thinning of the point by fluting, and (4) completion of the point by grinding. However, these clusters are neither well-defined nor entirely independent.

4. Additional attributes and controls for statistical interaction of attributes should be included in future studies of fluted points.

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